COMET: First Mission Progress[1]

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Abstract

The COMmercial Experiment Transporter (COMET) is a set of hardware and related infrastructure used to support orbital experiments of the CCDS's and their industrial partners. During the nineteen months since the program started, contracts have been signed, design reviews conducted on all components, experiments selected for the first mission, almost all hardware has been manufactured, and a majority of components have completed testing. The Program Office and CCDS Monitors took an active role in the development, planning, and conduct of the actions leading to the first flight of COMET scheduled in the first quarter of 1993. The Recovery System/Site has been exercised, and the Launch Facility is well on its way toward completion. As October came to a close, most of the major components of the COMET FreeFlyer have come together in League City, TX for an integrated test.

This report deals primarily with the programmatic issues which were resolved as the program matured. At times it is impossible to disassociate the technical from the programmatic and, in such cases, the technical material is presented to provide insight into the path selected by both the CCDS and Contractor Management.

COMET Overview

The COMET FreeFlyer will be launched with CCDS payloads aboard both the Service Module and Recovery System into a 300 nm circular orbit from the Conestoga Launch Vehicle. The non-recoverable Service Module will contain about 15

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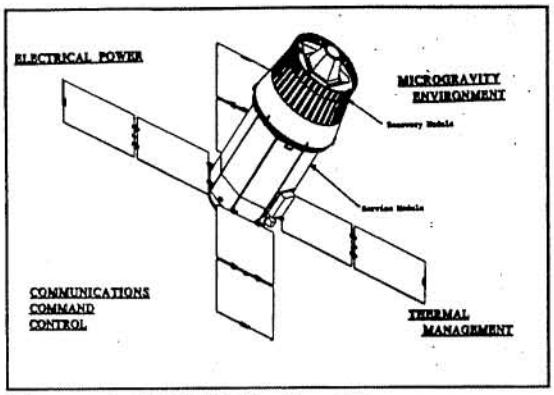

Figure 1 COMET's FreeFlyer

cubic feet of payload volume while the Recovery System will have about ten cubic feet. Command and control of the FreeFlyer and experiment data communications will be controlled through a Commercial Payloads Operations Control Center (COMPOCC) in League City, TX.

The Recovery System will separate from the FreeFlyer after about a month in orbit to be recovered near the Great Salt Lake Desert in the Utah Test and Training Range (UTTR).

Programmatic Overview

During the period of April 8, 1991, through October 30, 1992, the COMmercial Experiment Transporter progressed from Authorization to Proceed for the Contractors, Preliminary Design Reviews, Critical Design Reviews, Fabrication of almost all components, and testing of a majority of those components.

The Service Module has developed from original design, through fabrication of all components, and has undergone extensive testing, which has culminated in its arrival in League City, TX, for Integrated Testing. The Recovery System has followed almost the same path, however, with some perturbations in the spin table design, avionics/software design, and de-spin mechanisms. It has completed most of its testing and is currently ready for Integration Testing with the Service Module in League City, TX. The Commercial Payload Operations Control Center (COMPOCC) has developed into a fully operational control center, ready for operational status. Payloads have been selected, and the majority of them have completed unit testing and are being integrated into the Recovery System and Service Module. The Launch Vehicle has matured through its design process, with the Star 48V ready for installation, the Castor IV's being manufactured, the avionics ready for testing, and almost all mechanical items completed and being integrated. The Flight and Ground Software has been completed and is undergoing testing. The Launch Pad started in July 1992 and is ready for installation of the mechanical structures. The Recovery Site has been tested, and operational tests of the Recovery System have taken place.

The COMET System, as a total, is coming together partially in League City, and appears to be heading for an on-time launch in the first quarter of 1993.

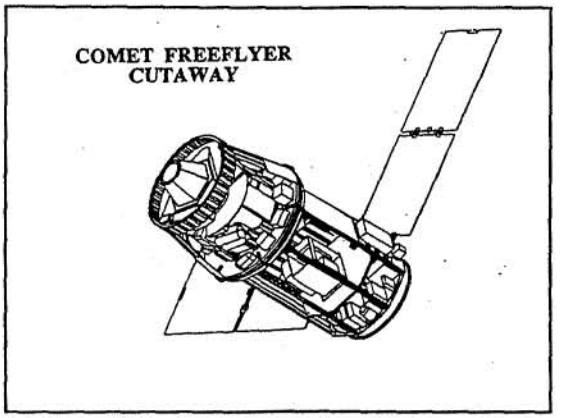

Figure 2 Payload Location

COMET STATUS UPDATE

Following is an update in the status of the COMET Program.

Payloads:

Following are the payloads manifested for COMET Mission #1:

Recovery System

[1] Biomodule	(Penn State)
[2] Non Linear Organic Thin Films and Crystals	(UAH)
[3] MDA Minilab	(UAH)
[4] Animal Autonomous Space Support Module	(BioServe)
[5] Plant Autonomous Space Support Module	(BioServe)
[6] Protein Crystal Growth-Batch (PCG-M)	(UAB)
Utility - Acceleration Measurement System (AMS)	(UAH)

Service Module

[7] Oxygen Atom Flux Monitors for Spacecraft(SURSAT)	(CMDS)
[8] * Autonomous Rendezvous and Docking (ARD)	(SpARC)

* Requires COMET Mission #2 for docking.

[9] Frozepipe (Frozen Heat Pipe Experiment)	(Texas A&M - CSP)
[10] LEOEX (Low Earth Orbit Communications)	(Florida Atlantic)

The Payloads have all been delivered to the Integration Contractor (SII) in League City, TX, and have undergone extensive testing in anticipation of Integrated Systems Testing with the Service Module, the Recovery System, and the COMPOCC.

The Autonomous Rendezvous and Docking Experiment (ARD) was delivered early to Space Industries, where it underwent fit checks and basic communication checks. ARD will remain on board the Service Module well past the 130 day mission with regular communication checks. It is only after the second COMET Service Module has been launched that this experiment will start its operation, being the target for the COMET #2 chase module. The chase module will target, operate, thrust, and observe the target vehicle without intervention from the ground, with an ultimate link-up and transfer of material.

SURSAT is an atomic oxygen flux monitoring experiment desiring proximity to the atomic oxygen present in Low Earth Orbit. It will be placed on the outside face of the Service Module, in the ram direction, and will remain in operation for the duration of the spacecraft's orbital lifetime.

Frozepipe is an experiment measuring the performance of heat pipes during extreme

temperature variations. It is manifested to be installed on one of the outside experiment panels.

LEOEX is a communications experiment testing various communication configurations in anticipation of future communications satellites.

Biomodule, MDA, NLO, and PCG-M are all experiments dealing with the growing of crystals in a microgravity environment.

AMASS and PMASS deal with plant and small animal tissue changes that occur in a microgravity environment.

One other component on the Recovery System is being provided by a CCDS, but is being flown as a utility on COMET. UAH is providing microgravity measurement equipment, similar to that flown on the Consort missions, to quantitize the microgravity disturbances during the mission. This is of particular importance to the crystal growing experimenters, who need to know the environmental conditions fairly accurately in order to assess the success of their experiments.

The Payload Integrators have integrated all experiments into their respective mockups, have communicated with simulators where applicable, and at the time of this writing are in the stage of being integrated into the Service Module, and Recovery System for communication with the FreeFlyer command and telemetry system, as well as the COMPOCC.

Launch Vehicle

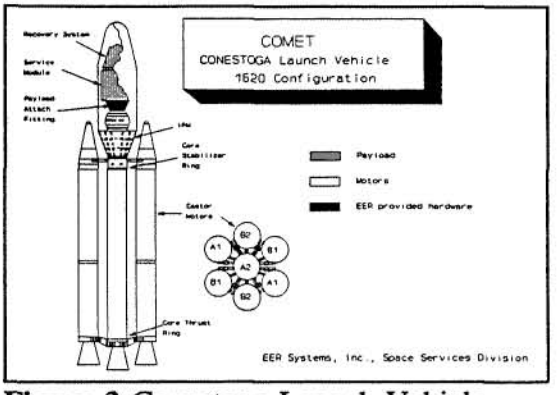

Figure 3 Conestoga Launch Vehicle

The Launch Vehicle has progressed from the initial design stage into the Conestoga 1620 depicted in figure 3. The core motor is a Castor IVB with thrust vector control. Attached to the core motor are four Castor IVA's and two Castor IVB's. On top of the core motor is a Star 48V, also with thrust vector control. Wind tunnel tests were conducted on the Conestoga 1620, with the results feeding into the thermal design, as well as the trajectory design.

Coordinationof the launch vehicle launch complex requirements with NASA has completed intense discussions, and on July 31, 1992, site construction commenced. The design of the Launch complex completed earlier this year; earthwork was finished in August, and pile driving/pile capping and structural concrete finished in mid October. The mechanical structures are nearing completion of fabrication and should start erection in November.

The Launch Vehicle Flight Software CDR was held in July, and Flight Software is undergoing the final

stages of testing. There have been some interface issues concerning the IMU, but all appears to be reaching a mutually agreeable solution. EER has elected to develop a state-of-the-art, AI based, Ground Control Software to relieve the burden on the launch control team from sifting through the myriad of status information provided shortly before launch. The system will be able to make intelligent choices on what data is important to the launch control team, and rapidly flag any out-of-nominal condition, as well as conditions where groups of data taken together indicate problems. The Ground Control Software will be ready for installation in December.

All mechanical and electrical Launch vehicle assemblies are in fabrication, testing, or are being integrated with the launch vehicle. Most avionics assemblies are in testing.

The Launch Vehicle appears to be on track for a first quarter launch.

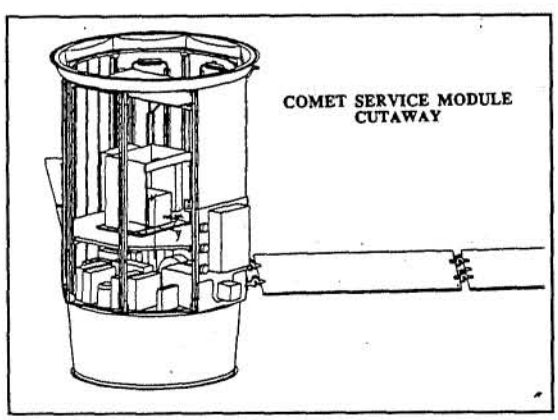

Figure 4 Service Module

Service Module

The Service Module has progressed completely through all phases of design, manufacturing, and testing, and is currently involved in Integration & Test in League City, TX. The design and manufacture has progressed very smoothly, with only minor problems with power controllers and some specialized electronics equipment.

One of the largest integration efforts on the COMET program involves the Capillary Pump Loop (CPL) - Thermal Control System that was provided to the COMET Service Module and Recovery System by OAO Corporation of Greenbelt, MD, under the supervision of Defense Systems Incorporated and Westinghouse. This effort took the technology from heat pipes, and some preliminary spaceflight results from OAO, and applied it to an engineering effort to develop a microgravity adaptable thermal control system. The OAO CPL system utilizes no mechanical pumps except for priming the system; therefore, there are no mechanical disturbances to interfere with the microgravity environment, and in particular, the crystal growth experiments. What was even more demanding of this integration effort, was the fact that the system is designed to operate in low gravity, and the passive-evaporation pumps do not work well in a one-gravity environment that they are tested in here on Earth. The program had a number of setbacks in fabricating and characterizing the system, but in the end, the OAO/DSI/Westinghouse team has delivered a unique system specifically adapted for the

requirements of COMET. The Recovery System is also incorporating the OAO CPL system.

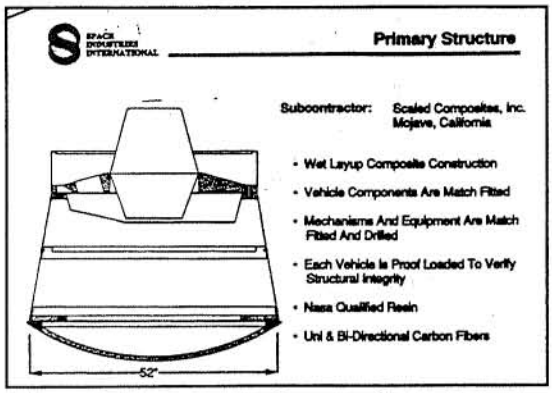

Figure 5 Recovery System Structure

Recovery System

The Recovery System is nearing completion, with most of the major components currently undergoing Integration and Test in League City, TX. The Avionics supplied by the SouthWest Research Institute have been integrated into the flight system along with SII supplied software, have undergone testing, and are being tested with the Recovery System experiments.

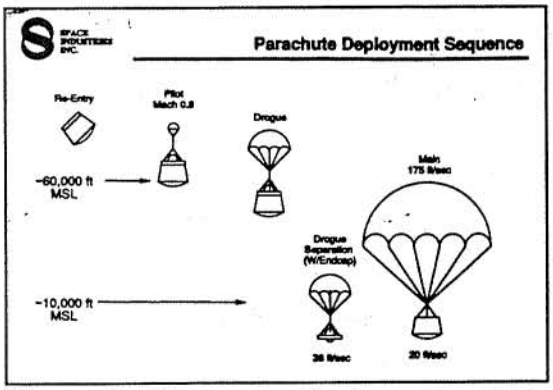

Figure 6 Recovery System Parachute Deployment

The Parachute & Airbag systems have been extensively tested, starting with a 20-ft drop test to check the operation of the airbag. The next test involved dropping a protoflight model of the recovery system from a privately-owned Canberra from 20,000 feet. This test successfully tested the limits of the main chute and the deployment of the airbag. The most recent test involved dropping the protoflight unit from the Canberra in excess of 50,000 feet to test the deployment of the drogue chutes, as well as the main chute and airbag. This test was conducted at UTTR and exercised the UTTR & SII Recovery Teams. The test was completed successful, with complete recovery and disassembly in less than four hours.

Space Industries has studied the re-entry aerodynamics extensively, and determined that in order to meet the landing range dispersion requirements, the Recovery System will have to spin up before the retro-motor fires in order to compensate for off-axis thrust of the retro-motor. This, in turn, entails a de-spin mechanism be incorporated. SII has successfully designed, built, and tested a Yo-Yo de-spin system in record time in order to meet this required change.

Another area of concern for SII has been the design of the spin table/spin bearing that mates the Recovery System to the Service Module and allows for the spin-up of the Recovery System just prior to separation. This item has been plagued by a number of engineering anomalies, and Space

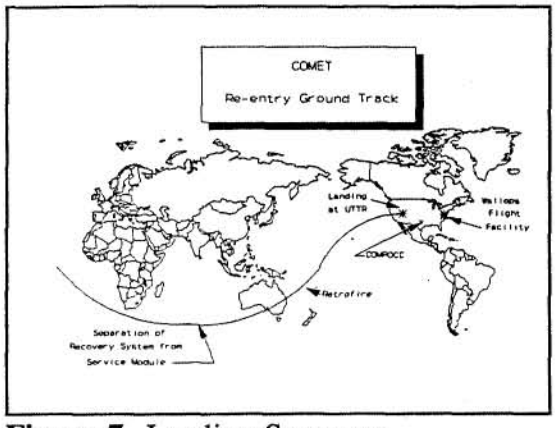

Figure 7 Landing Sequence

Industries appears to have solved all of the major problems associated with the thermal expansion of the bearings and associated race-ways.

Overall, the Recovery System appears to be ready for launch after Integration & Test.

Orbital Operations

The COMPOCC has evolved into a fully functional Satellite Control Center with fully operational

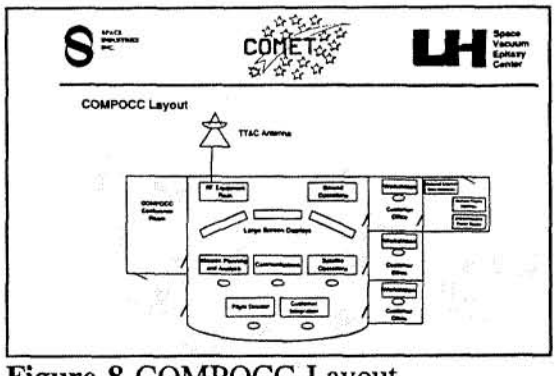

Figure 8 COMPOCC Layout

workstations, computer networks, data storage facilities, and an operational command and control software system. They have installed a fully operational Tracking, Telemetry, and Command system consisting of a Scientific Atlanta antenna and receiving station and have fully tested it with satellites on orbit and the COMET FreeFlyer in League City.

Other Programmatic Issues

Gunn Report

In May, 1992, Mr. C. Gunn of NASA Code SV was asked to provide a non-advocate program review of COMET. On May 27 & 28, 1992, the COMET Management Team and the CCDS Monitors presented a technical overview of the complete COMET program, from contracts & finance to ordnance system design. Overall, the review team was favorably impressed, and forwarded a set of 18 recommendations to Code C and the COMET Team. All the reccomendations have been reviewed and feedback provided to the Gunn Committee.

SUMMARY

The COMET Program is in the midst of Integrating a myriad of different components from suppliers and contractors scattered across the U.S., and has just started the testing of this collection of highly-technical components. To date, only minor problems have occurred, and the COMET Team has responded with one voice and quickly vanquished those marauding gremlins of doom. COMET nears its first launch, and from software,

to hardware, to launch pad, the whole COMET team is pointing in the right direction, and it appears that we'll have a some real COMET carrier waves coming from 300 miles up before the end of March.

List of Major COMET Contractors and Suppliers

Service Module

Westinghouse - Prime Contractor

Defense Systems Inc. - Service Module Manufacturer

OAO Inc. - Thermal Control System Supplier

Space Sciences Corp. - Attitude Control Systems

Kearfott-Siegler - IMU

Recovery System

Space Industries Inc. - Prime Contractor

Pioneer - Parachute Systems

Scaled Composites - RS Structure

SouthWest Research Institute - Avionics

Launch Vehicle

EER Systems, Inc. - Prime Contractor

Morton Thiokol - Motors

Logicon Control Dynamics - Flight Software

Altair Aerospace Corporation - Ground Control Software

Tracor - Fairing

Orbital Operations

Space Industries Inc. - Prime Contractor

Space Applications Corporation - Software Development

Payload Integration

Space Industries Inc. - Prime Contractor

SouthWest Research Institute - Environmental Testing